COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF TELECOMMUNICATIONS AND ENERGY

D.T.E. 05-27

BAY STATE GAS COMPANY

DIRECT TESTIMONY OF JON R. CAVALLO, PE, PCS

On behalf of

THE OFFICE OF THE ATTORNEY GENERAL

July 15, 2005

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I. STATEMENT OF QUALIFICATIONS

Q. Please state your name and business address.

A. My name is Jon R. Cavallo. My business address is 235 Heritage Avenue, Suite 2, Portsmouth, New Hampshire.

Q. What is your present occupation?

A. I am a consulting engineer specializing in corrosion mitigation and protective coatings.

Q. Please summarize your professional experience.

A. I am a Registered Professional Engineer in seven states and hold a Bachelor of Science Degree from Northeastern University. I am a SSPC Protective Coating Specialist and a NBR Certified Nuclear Coatings Engineer. I am active in a number of professional associations including ASME, ASTM, NACE, NSPE, and SSPC. I serve as the Chairman of ASTM Committee D-33. I also served as the Chairman of the Steel Structures Painting Council (SSPC) Northern New England Chapter from 1991 through 1997 and the reorganized New England Chapter from 1999 to the present. I am a Director on the Board of the Maine Society of Professional Engineers. My over 30 years of experience in industrial surface preparation and painting includes engineering, contracting and equipment design/manufacturing at a senior management level.

Q. What experience do you have in the corrosion performance of buried piping?

A. During my career, I have evaluated the performance of buried piping and designed corrosion mitigation programs for clients throughout the world. My experience includes development of the buried pump station piping corrosion mitigation program for the Aleyeska Pipeline Service Company, evaluation of underground steel infrastructure corrosion at the Voice of America relay stations in Sao Tome and Botswana, and serving as the independent reviewer for restoration of the safety-related service water piping at Duke Energy's Catawba Nuclear Station.

Q. What experience do you have in designing steel corrosion mitigation specifications for natural gas companies in the northeastern United States?

A. I have performed work for the Boston Gas Company (now KeySpan) for many years. My work has primarily involved developing protective coating specifications for atmospheric and buried structures, and performing on-site advisory services during work-in-progress, including reproduction of the Corita "Rainbow Tank" design at KeySpan's Dorchester, Massachusetts LNG facility.

Q. Please describe your educational background.

A. I hold a Bachelor of Science in Engineering Technology with Honors from Northeastern University, Boston Massachusetts. My post-graduate education includes the following courses: University of Washington, Cold Regions Engineering; University of Colorado, Engineering Project Management; NACE, Corrosion Prevention in Oil and Gas Production; University of New Hampshire, Finance for the Non-Financial Manager; Fairleigh Dickinson University, Inspection, Evaluation and Rehabilitation of Highway Bridges; The Hartford Graduate Center, Value Engineering.

II. BACKGROUND AND SUMMARY OPINION

Q. On whose behalf are you testifying?

A. I am testifying on behalf of the Office of the Attorney General of Massachusetts.

Q. What is the purpose of your testimony?

A. I have been asked to comment on the Bay State Gas Company's (Company) Steel Infrastructure Replacement (SIR) Program; the effect of underground pipe coatings on corrosion; the performance of unprotected coated steel pipe (UPCS or coated pipe);[1] the probable cause of the increased leak rate in the Bay State Gas Company buried piping; the acceptability of the Bay State Gas Company leak repair and main

[1] "Unprotected coated steel pipe" is steel pipe with a non-conductive coating applied, but no additional defense against corrosion provided by a system of cathodic protection.

replacement program; and the relationship (if any) between higher gas pressure and increased corrosion.

Q. Have you reviewed the current Bay State Gas Company Steel Infrastructure Replacement (SIR) program?

A. I have reviewed a number of documents provided by Bay State Gas Company to the Attorney General related to the SIR program, and I have reviewed various transcripts of testimony given in this matter. It is my understanding that the Attorney General has requested additional documents from Bay State Gas Company related to the SIR program, and I will review these additional documents when they are produced, and reserve the right to supplement my testimony accordingly.

Q. Have you had the opportunity to observe the condition of any of the buried Bay State Company gas mains in the field?

A. I have. At the request of the Attorney General, Bay State Gas Company arranged for a representative of the Attorney General's Office and me to observe the pipe conditions and excavation procedures of two Company repairs to detected Type II leaks on June 29, 2005. I observed leaks on a bare steel main and unprotected coated main located near a residential service. My field note observations during that visit follow:

<u>Dogwood Lane, Marshfield, MA</u>

Normal system pressure is 50-60 psi, maximum 99 psi according to Cote

3 in dia bare steel pipe with two leaks, both along shop weld seams

According to Cote, pipe was installed 31 years ago (actually installed in 1931, according to Company gas maps)

Repairs made with 2 - 6" long clamps

Installed 17lb Mg anode using cadweld

Wrapped clamps and anode connection using wax tape

106 Colonial Road, Marshfield, MA

1952 1.5 in dia main coated with bitumastic coating, 1960's 1 in dia service connection coated with bitumastic coating

Leak due to pinhole corrosion at top of pipe

Repair made with 1- 6" long clamp

Installed 3lb Mg anode using cadweld

Wrapped clamps and anode connection using wax tape

Pipe scraped and wrapped with Tapecoat T Tape

Q. **Could you summarize any opinions concerning the Bay State Gas Company SIR program?**

A. Yes. Based upon the documents that I have reviewed and the transcripts that I have read, as well as my field observations and general experience, it is my opinion that the SIR program is not based on sound engineering practices, and should not be adopted as proposed by the Company. First and in particular, it appears that no effort has been made by Bay State Gas Company to determine the root cause(s) of the increasing leak rate in its underground infrastructure. Second, it appears that Bay State Gas

Company has made no effort to identify areas and material types in its underground distribution system that are more prone to corrosive attack, and accordingly structure the priorities of its SIR program based on robust corrosion engineering principles.

Q. Can you explain why it is important from an engineering perspective to determine the root cause of the increasing leak rate?

A. Yes. A root cause analysis would explain the apparent paradox, as presented by Bay State Gas Company, that as the Company continues to replace mains and services, its leak rate continues to rise. The age of a pipe alone will not fully explain a rising leak rate as the material ages in the ground, because in theory if a pipe were completely protected from all corrosive forces, it would last indefinitely. Identification of the root cause will allow the Company to target its ongoing replacement efforts and avoid this problem in the future. Without this knowledge, the Company runs the risk that it may unwittingly replicate conditions that will cause future corrosion and leak problems in its repaired and replaced infrastructure.

Q. Are the reports prepared by R.J. Rudden Associates a root cause analysis?

A. No. Although R.J. Rudden spent several months studying data and retained Heath Associates, a leak detection company, in conjunction with its review, the reports do not independently attempt to determine the root cause of the Company's increasing leak rate. Instead, R.J. Rudden proposed several replacement schedules for mains and services.

Q. What is your estimate of how much a root cause analysis would cost?

A. Based on my current understanding of the Company's infrastructure, I estimate that a root cause analysis should cost no more than $40,000.

III. COMMENTS

Q. Could you provide some background information on the general regulatory requirements for pipe coatings and corrosion mitigation?

A. Yes. In order to understand coatings on buried gas pipes and corrosion mitigation as it relates to the Company's configuration of its materials in its distribution system, it is important first to know that federal regulations changed in the early 1970s. The new regulations require that buried pipelines installed after July 31, 1971, such as those installed and operated by Bay State Gas Company, be protected against external corrosion.[2] This requirement is normally met by pipeline operators employing a "defense-in-depth" approach involving application of a high-performance coating to the exterior of the pipe and installation of a cathodic protection system within 1 year after completion of construction. The new regulations also

[2] 49 C.F.R. 192.445.

impose a set of requirements for previously installed unprotected coated steel to be retrofitted with cathodic protection.[3]

Prior to July 31, 1971, buried steel gas pipe consisted of either bare steel, or bare steel externally coated with a protective coating. According to testimony by Bay State Gas Company employees, documents produced by Bay State Gas Company, and my observations during the site visit on June 29, 2005, the Bay State Gas Company underground distribution system uses both bare steel and unprotected coated steel in all three of its service territories.

Q. Could you explain the relationship between coatings on buried steel pipe and corrosion mitigation?

A. Yes. The coating plays a critical role in preserving the underlying steel from corrosion. In order for corrosion of steel to occur, four elements must exist: an anode, a cathode, an electrical conductor connecting the anodes to the cathodes, and an electrolyte which, in the case of buried pipe, is the soil surrounding the pipe that permits the corrosion current to flow. For gas pipe, the anodes, cathodes and electrical conductors are inherently part of the steel pipe and thus cannot be separated from each other.

[3] 49 C.F.R. 192.457 (details of the requirements).

Bare steel pipe allows the surrounding soil (the electrolyte) to be in intimate contact with the steel pipe and, unless another outside influence is in place, the pipe will uniformly corrode. If, however, the surrounding soil contains anomalies (such as stones in the backfill and/or bedding) which are pressed against the bare steel pipe, the area of influence will suffer accelerated corrosion and, eventually, localized failure of the pipe.

Corrosion of bare, non-cathodically protected, pipe is reduced by coating the pipe exterior with a non-conductive barrier coating film, which isolates the electrolyte (the soil surrounding the pipe) from the steel surface of the pipe. This technique was used for many years prior to the advent of cathodic protection to protect buried steel structures from corrosion. If, however, the coating film is damaged by anomalies in the soil surrounding the pipe (such as stones in the backfill around the pipe and/or bedding under the pipe), either during the burial of the pipe or due to in-service movement of the pipe in the soil (from frost action, for example), the coating film may become locally compromised. If the pipe coating is damaged, the result will be localized accelerated corrosion and, eventually, localized failure of the pipe.

Q. Could you explain why a coated steel pipe without cathodic protection will experience accelerated corrosion if the pipe coating is damaged in some way?

A. Yes. The corrosion which occurs at a damaged pipe coating site is far more severe that the localized corrosion which occurs on an uncoated (bare) pipe in intimate contact with the same soil anomaly. In the case of a damaged pipe coating, the exposed steel substrate is a very small anode when compared to the surrounding large cathode area of the coated pipe. As such, corrosion of the area of damaged coating will occur at a greatly elevated rate, even if the soil anomaly (for instance, a stone) which caused the coating damage is no longer in contact with the pipe. In simpler terms, the corrosive forces along the surface area of the coated pipe focus on the small area of exposed steel and accelerate corrosion.

Q. Does this dynamic present any special problems for the Company?

A. Yes. The Bay State Gas Company distribution system uses both bare steel and unprotected coated steel, but the Company treats the coated pipe as if it was same as the bare in the justification for accelerated replacement under its SIR program. The unprotected coated pipe represents only about 18% of the mains to be replaced under the SIR program, but may exhibit a higher leak rate than the bare steel. According to the information produced in this proceeding regarding the Company's efforts to retrofit its coated steel pipe with cathodic protection, the Company has known since the mid-1980s that the coatings on its remaining unprotected coated pipes have been compromised. It would be reasonable to conclude that these pipes would experience a higher leak rate.

Q. Have you reviewed the Company's SIR program?

A. Yes, I have, but only from a technical standpoint.

Q. Do you have any opinions concerning the technical adequacy of the Company's SIR program?

A. Yes, I do.

In my opinion, the technical basis for the Bay State Gas Company SIR program is not sound or supported by the technical data the Company has provide to date to the Attorney General.

My primary reasons for this opinion are:

1. Based on the manner in which Bay State Gas Company maintains its corrosion failure records, it is not possible, in the brief amount of time allocated for review, to determine whether a corrosion failure occurred in a bare steel pipe or in an unprotected coated pipe and confirm the calculations for the leak rates for these two different materials presented by the Company in the response to AG 2-1. Without being able to separate and trend corrosion failures in the two different types of material, it is not possible for me to definitively state the corrosion rate for either type of pipe.

2. The R.J. Rudden reports, which encompass several months of study of the Company's records and industry data, also do not differentiate between corrosion failures of bare steel pipe and unprotected coated steel pipe. The R.J. Rudden reports contain postulated asymptotically increasing corrosion failure rate charts and tables concerning unprotected steel pipe which are not supported by data currently provided by the Company. In fact, the in exhibit BSG/DGC-3 produced by Bay State Gas Company shows that total number of leaks categorized as "Corrosion" exhibit a progressively *downward* trend from the period 2000 to 2004

3. Based on the Company's answers to discovery, the Company has apparently made no attempt to determine the root cause of any of the corrosion leaks in its systems. For example, see the response to AG 14-11 ("because Bay State conducts continuous leak surveys, it has not found the need to contract outside consultants for additional expertise regarding corrosion or leaks in the Bay State distribution system") and the June 21, 2005, Opposition to the Attorney General's motion to compel a response to AG 2-18 (no reports on external causes of corrosion). Since Bay State Gas Company has made no verifiable attempt to determine the root cause(s) of the corrosion leaks in its system, there is no way in which it can set priorities for its SIR program nor judge the severity of the pipe

corrosion in its system, much less prevent corrosion or leaks in the future when it replaces buried piping.

Q. **Do you currently hold any opinions concerning the probable root cause of the increased leak rate in the Bay State Gas Company unprotected buried piping?**

A. I do.

In my opinion, the cause of the pinpoint leaks in Bay State Gas Company's unprotected buried piping is the poor quality of bedding and backfill which surrounds the piping. In my opinion, the corrosion of the unprotected piping is increasing, but not at the dramatic and asymptotic rate claimed by Bay State Gas Company and its consultant in the R.J. Rudden reports. I base these opinions on the following:

=> On June 29, 2005, I was able to observe the excavation of two areas of pipe leaks. Bay State Gas Company selected these areas. One area involved a bare steel pipe, and the other area involved an unprotected coated steel pipe. In both cases, the fill removed from the excavation and subsequently replaced in the excavation contained materials that could impinge upon the pipe and did not meet the Company's own standards for bedding and backfill material as required in its Operating and Maintenance Procedures Manual, §4.05 (Trench Padding and Backfilling Procedure For Mains), §10.3 (Pipe Bedding and Final Backfilling – Material

Standards) (“For 6” and smaller pipe, maximum particle size should be ½”). I am aware of no coatings manufacturer that recommends the placement of stones or other debris that may damage the coating against the surface of a coated buried steel pipe.

The backfill removed and replaced in the excavations contained both large and small stones, round and sharp, which had probably been in contact with the affected pipes before excavation and would, in all probability, come in contact again with the pipe after repairs were completed. The workers at the excavation site made no attempts either to install clean and competent bedding or initial backfill in the excavation after repairing the pipe. There was no separate supply of clean fill on hand at the site. When asked at both sites if this backfill procedure was a typical example of Company work, Mr. Cote confirmed that it was.

The site photographs identified below are attached to my testimony.

PHOTO NUMBER	**SITE LOCATION**	**DESCRIPTION OF CONDITION**
JRC-1	Dogwood Lane	Note stones in close proximity to pipe leak
JRC-2	Dogwood Lane	Note stones from proximity of leaking pipe in fill removed from excavation
JRC-3	Dogwood Lane	Pipe repaired and ready for burial – note stones in

		close proximity to pipe
JRC-4	Dogwood Lane	Original fill containing stones pushed back into excavation by backhoe
JRC-5	Dogwood Lane	Fill containing stones compacted onto pipe after repair
JRC-6	106 Colonial Drive	Note large stone in close proximity to pipe
JRC-7	106 Colonial Drive	Note numerous stones in close proximity to pipe
JRC-8	106 Colonial Drive	Note numerous stones in fill from excavation – later re-deposited in excavation and compacted

Q. Do you have an opinion as to whether higher gas pressures exacerbate external corrosion on steel pipes?

A. I do.

In my opinion, gas pressure has no effect on the external corrosion rate of buried gas pipe. Corrosion of the external surface of a buried gas pipe will proceed from the exterior of the pipe inward until the minimum wall thickness is violated; in other words, when the thickness of the pipe is not sufficient to contain the gas inside the pipe. At that time, the pipe begins to leak.

Q. Do you have an opinion as to the acceptability of the current Bay State Gas Company Leak Repair and Main Replacement Program?

A. I do.

In my opinion, the current Bay State Gas Company Leak Repair and Main Replacement Program is inadequate primarily because of Bay State Gas Company's failure to identify the root cause of the corrosion of its existing infrastructure. If Bay State Gas Company were to identify the mechanisms causing corrosion in its existing infrastructure, it would be able to target its efforts on the material with the highest corrosion rates first and to prevent reoccurrence of the leak problems on replacement mains and services.

As it stands now, there is little guarantee that the SIR program, as currently proposed, will be a technically successful "path forward." Blindly applying impressed current cathodic protection to new, coated pipe as it is installed is not a cure for poor construction installation practices, including for bedding and backfilling with substandard materials.

Q. Does this conclude your testimony?

A. Yes.